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DENTAL COMPRESSED AIR SYSTEMS

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The purpose of this report is to update guidelines on dental compressed air systems (DCA). Much of the information was obtained from a survey of 128 compressed air systems throughout the Air Force. Air quality requirements are outlined. The general design and description of each part of a typical system is analyzed. Information needed to design a DCA system for a new facility is discussed. Many types of compressors are available and are being used by dental facilities. This report describes the general function of each type of compressor, listing advantages and disadvantages of each. Other components of the DCA system are also reviewed. Certain unique problems that may be of interest to some installations are discussed. Whenever possible, selection recommendations are made.

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DENTAL COMPRESSED AIR SYSTEMS

1. INTRODUCTION

This document replaces Central Dental Compressed Air (DCA) Systems (USAFSAM-TR-86-7, May 1986) and Central Dental Surgical Handpiece Drive Air (SHDA) Systems (USAFSAM-TR-86-8, May 1986). It also includes data obtained from a survey of 128 compressed air systems (DIS Project 91-06).

Section 2 of this document discusses air quality requirements of the Dental Compressed Air (DCA) System. Section 3 discusses the varying components of the DCA System. Unique problems that may be of interest to some installations are addressed in Section 4. Finally, a brief conclusion, bibliography, glossary, list of company addresses, and several component checklists are included. Acronyms used in the body of the report are defined in the glossary.

2. AIR QUALITY REQUIREMENTS

2.1 General

DCA systems must provide clean, dry air to minimize corrosion and rusting of dental equipment, to prevent contamination of oral structures, and to maximize power from air driven instruments. Thus, they are unique compared to many other compressed air systems.

DCA is used to power dental handpieces, sandblasters, power lifts, etc. It does not supply breathable air and is never used for life support systems. Medical Compressed Air Systems are strictly regulated as to allowable concentrations of carbon monoxide, carbon dioxide, dew point, etc. It is expensive to purchase and maintain the equipment needed to purify and monitor medical air. DCA is not required to meet the same stringent standards as Medical Compressed Air.

The major contaminants of compressed air are condensed **water vapor**, **oil** (occasionally referred to as condensed hydrocarbons), and **particulates**.

2.2 Limits of Water Vapor Contamination

Water, in its gaseous form, is not a problem because it behaves essentially as any other gas. It is when this water vapor condenses into water droplets that problems begin. Condensed water can cause corrosion, erosion of surfaces, loss of lubricant, reduced power output from air-powered equipment, and contamination of tooth surfaces intended for bonding. For compressed air systems, the amount of water vapor in the air is measured in terms of the air's dew point.

For DCA, the dew point should not be greater than 4°C (38°F) at 7 kg/cm^2 (100 psig). When air is expanded back to atmospheric pressure (e.g., discharging air from a 3-way syringe), it will have a dew point of 16°C (-4°F) (equivalent to a relative humidity of 3%). This air will quickly dry moist surfaces and will eliminate most problems due to water condensation in the dental clinic.

NOTE: If the air lines are routed through unheated areas which are exposed to temperatures less than 0°C (32°F), the dew point should be lower (see Special Topic #4.5).

2.3 Limits of Oil Contamination

Generally, oil contamination is introduced by the compressor. The degree of contamination is measured in parts-per-million by weight (ppm w/w). The maximum acceptable limit for oil in DCA is 0.05 ppm w/w.

2.4 Limits of Particulate Contamination

Particulate contaminants must be filtered down to at least 1 micrometer (μm) before entering the building's air lines.

2.5 Air Pressure Requirements

The DCA system must be able to provide air pressure at the Dental Treatment Room (DTR) between 5.6 - 6.3 kg/cm^2 (80-90 psig). For clinics using the DCA for surgical handpieces, refer to **Special Topic #4.4**. Some dental laboratory air stations require a reduced pressure between 1.8 - 2.2 kg/cm^2 (25-30 psig). This pressure can be obtained from the higher pressure DCA system through the use of an air regulator near the point of use.

When air flows through air lines and equipment, its pressure decreases. This pressure loss must be considered when setting and adjusting the DCA pressure settings. For a typical system, during full flow conditions, the average pressure loss and final pressure would be:

kg/cm^2	psig	
7.00	100	(DCA's minimum initial air pressure)
-.14	-2	(aftercooler's pressure drop)
-.35	-5	(refrigerated dryer's pressure drop)
-.28	-4	(filters' pressure drop)
-.35	-5	(pressure drop due to building's air lines)
5.88	84	(final pressure at the DTR)

NOTE: When designing a system for a new facility where there are long air lines (i.e., > 15 m (50 ft), most mechanical engineers allow for a 1% loss in pressure per 3 m (10 ft) of line.

The DCA system should consist of a lead and a lag compressor. The lead compressor is the first to start as the air pressure falls; the lag compressor starts at a lower pressure if the lead compressor cannot supply enough air. In this example, the lead compressor would be set to start at 8.1 kg/cm^2 (115 psig) and run until it reaches 9.5 kg/cm^2 (135 psig). The lag compressor should be set to start at 0.7 kg/cm^2 (10 psi) lower than the lead compressor. Therefore, the lag compressor would be set to start at 7.4 kg/cm^2 (105 psig) and stop at 8.8 kg/cm^2 (125 psig). As the coalescing filters fill with debris and liquid, the pressure at each compressor may change as much as 0.7 kg/cm^2 (10 psi); thus, the lead and lag compressors' starting and stopping pressures may need to be set as much as 1.4 kg/cm^2 (20 psi) higher. The final pressure to the building's air lines is kept constant by a regulator placed after the filters and dryer (see Figure 1).

2.6 Air Flow Requirements

The suggested air flow requirement for each DTR is based on a survey of existing DCA Systems and is 57 lpm (2.0 cfm) at 7 kg/cm^2 (100 psig) (measured at each compressor). Thus, the total compressor capacity (2 compressors) should be 113 lpm (4 cfm) per DTR. This value takes into account the random air flow demands due to high-speed handpieces, low-speed handpieces, and three-way syringes used by the dental clinic. If the dental clinic is equipped with an Air Venturi System (AVS) or any air-operated evacuation system instead of central vacuum, each DTR's demand will be increased by 127 lpm (4.5 cfm) to 184 lpm (6.5 cfm) at 7 kg/cm^2 (100 psig). The air demands of an attached dental laboratory are minimal and will generally be met without increasing the size of the DCA system. If the dental laboratory is remote, or otherwise requires a separate compressed air system, a total of 113 lpm (4.0 cfm), at 7 kg/cm^2 (100 psig) is required.

3. COMPONENTS

3.1 Compressed Air System, General Design

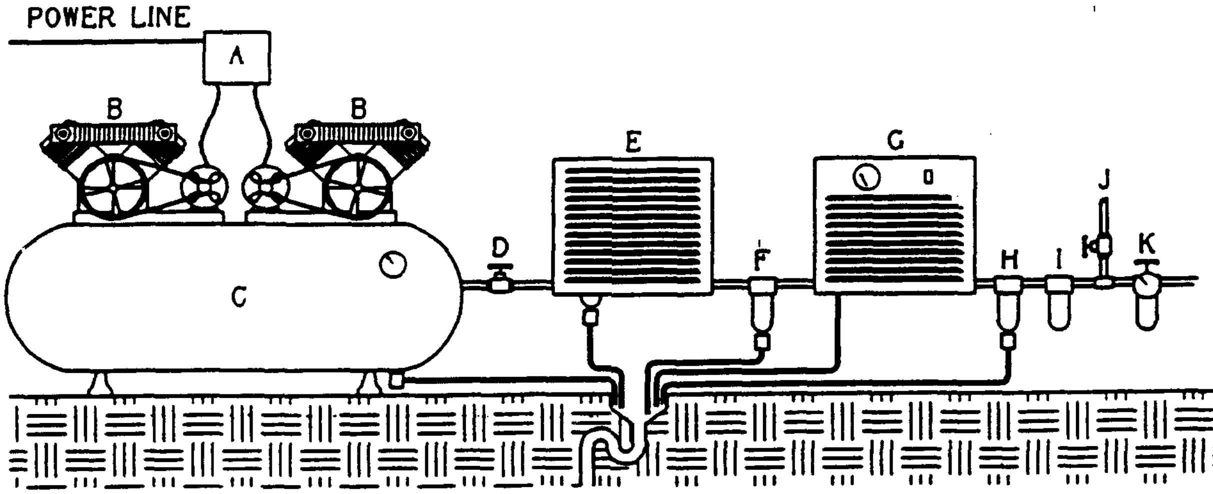
A DCA System is shown in Figure 1. Note that although the two compressors utilize one air receiver, they must function separately. If one compressor fails, the other could serve as a backup, thus, preventing total loss of air. Each of these sub-systems will be discussed in detail below.

3.2 Control Panel

The control panel consists of an alternator that operates each compressor alternately (i.e., runs the first compressor one time and the other compressor the next time). The panel also controls the function of both the lead and lag compressors. If the compressors were not alternated, mechanical wear would not be equal and the lesser used compressor would be more susceptible to corrosion. Eventually, it could fail.

The DCA System should also contain a low pressure monitor and test button that sounds an audible alarm when the air receiver's air pressure falls below

7 kg/cm^2 (100 psig). The audible alarm should be located in the administration, records, or reception area of the dental clinic.



A - Control Panel with Alternator
B - Compressors with Intercoolers
C - Air Receiver with Drain & Gauge
D - Service Valve
E - Aftercooler with Separator & Drain
F - General Purpose Coalescing Filter
G - Refrigerant Dryer
H - Final Coalescing Filter
I - Vapor Removal Filter
J - Air Sample Tap
K - Pressure Regulator

Figure 1. Dental compressed air system.

3.3 Compressors

All DCA systems must have two equally-sized compressors, each having the capability to handle the entire load of the dental clinic with no more than a 65% duty cycle. This configuration gives adequate reserve capacity and sufficient cool down time to prevent overloading. Under normal operating conditions, with both compressors alternately running, the actual duty cycle should not exceed 33% for each compressor. As mentioned previously, the two compressors can utilize one air receiver (Fig 1) or separate receivers. Compressors using oil lubrication must have a low oil or a high temperature shutdown switch.

Heat of Compression:

Compressing air raises its temperature. This temperature rise creates additional resistance to compression, reduces efficiency, increases mechanical wear, increases operating costs, and lowers reliability. For example, a single-stage compressor raises air pressure from atmospheric to the final pressure in one stroke. Single-stage compressors may have more than one piston, but each piston raises the air to its final pressure in one piston stroke. Since there is very little cooling during compression, these units

produce very hot air, about 232°C (450°F) for 6.3 kg/cm^2 (90 psig) air. Therefore, single-stage compressors should be limited to air pressures of 5.6 kg/cm^2 (80 psig) or less. They are not recommended for DCA systems.

Heat Reduction:

There are two major methods of heat reduction: multi-staging and injection cooling. One of these methods should be employed to reduce heat for pressures above 5.6 kg/cm^2 (80 psig).

Dental air compressors which utilize multi-stage compression are known as two-stage compressors. In the first stage, the piston compresses the air from atmospheric pressure to about 2.8 - 3.5 kg/cm^2 (40-50 psig). The air is then cooled by an intercooler and compressed to its final pressure in the second stage. Air intercoolers are commonly used on dental compressors. Water intercoolers, even though more effective, are options that are usually not needed.

Injection cooling works by injecting a liquid (usually oil or water) with the air into the compressor, then compressing the mixture, and finally separating the liquid from the air. The liquid may then be discharged or cooled and reused. This process is successful in removing most of the heat because the liquid has more mass and a higher specific heat than the compressed air.

3.3.1 **Electric Motors**. The voltage, phase, and frequency (50/60 Hz) of the motors used in the DCA system must match the electrical supply. Using a boost transformer to raise building voltage to match a motor is more expensive and less reliable than ordering the correct motor to match the electrical supply. Boosters are not recommended. Triple-phase motors are preferable over their single-phase counterparts since they give better performance, are less expensive, and are more reliable.

Starting an electric motor produces a very large momentary surge of current (about 5 times the normal current load) causing additional heating of the motor. Motors started too often will overheat and eventually fail prematurely. Motors used for DCA should be limited to less than 6 start-ups per hour. Unnecessary motor start-ups can be reduced by installing a correctly sized receiver or by running the motor continuously using valves within the compressor to control the air flow (i.e., using a constant-speed control and loading and unloading the compressor).

3.3.2 **Other Factors Concerning Compressors**. Special considerations must be made for clinics at elevations above 1500 meters (5,000 feet). Air is thinner at higher elevations; consequently, compressor capacity (in kg/cm^2 or cfm) drops. The thinner air will not properly cool standard motors at higher elevations. Special compressors and motors are often required. The manufacturer should be consulted for the correct configuration of equipment.

Compressors are most commonly mounted on top of the air receiver (duplex tank mounted); however, they can also be remotely located on skids. If compressors are remotely located, the air lines between the compressor and the air receiver must have pressure relief valves to maintain a constant pressure between the compressor and receiver and to prevent rupturing the air line.

Before installing a DCA system, the physical size and weight of the compressors must be considered. There must be enough room to move them through doors, through access shafts, down hallways, etc. Special installation arrangements may be required. For example, a 3-hp duplex tank-mounted compressor may weigh over 450 kg (1,000 lb) and may be 1.8 m (6 ft) long, .9 m (3 ft) wide, and 1.2 m (4 ft) high.

3.3.3 Types of Air Compressors. There are many types of compressors that can be successfully used for DCA. To help demonstrate compressor efficiency at 7 kg/cm^2 (100 psig), specifications on 49 compressors made by 13 manufacturers were used to construct Figure 2. Many companies offered compressor types in at least two or three categories (i.e., lubricated reciprocating, nonlubricated reciprocating and rotary screw compressors). The ranges of data are shown by the bars. Figures 3, 4, and 5 are from a survey of 128 DCA Systems (DIS Project #91-06). Figures 3 and 4 represent the age of units in military clinics, not the life expectancy of these units.

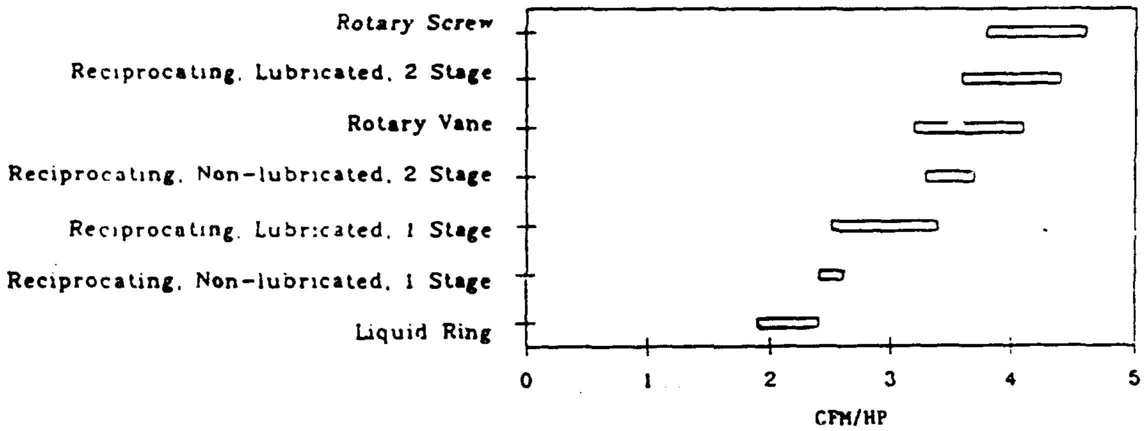


Figure 2. Air compressor efficiency.

3.3.4 Lubricated Reciprocating Compressors. In the lubricated reciprocating compressor, a piston travels inside a cylinder which is lubricated with oil. As the piston moves up and down compressing the air, a small amount of oil vapor is transferred with the compressed air. This oil vapor is later removed by a series of filters. Reciprocating compressors are available in single and two-stage configurations. For most dental applications the two-stage compressor is preferable.

Two-stage lubricated compressors are initially, as a group, some of the least expensive compressors, and they offer very good reliability as evidenced from the survey (DIS Project 91-06). Although variable, the approximate cost for maintenance of a two-stage compressor is $900 a year (provided the maintenance is accomplished as recommended by the manufacturer). They are among the most efficient compressors and, according to the survey, have long operational lives. They can be operated over a large range of pressures (generally up to 14 kg/cm^2 [200 psig]).

3.3.5 Nonlubricated Reciprocating Compressors. The nonlubricated reciprocating compressor operates on the same principle as the lubricated compressor except that the piston rings are made of a low friction material (usually a Teflon-composite) The piston walls are oil-less and all friction reduction between the piston and cylinders is due to the low friction piston rings. Generally, because of this design, these compressors cannot operate at as high a pressure as the lubricated reciprocating compressors and are usually limited to a maximum of 8.8 kg/cm^2 (125 psig). Once again, these compressors are available in single and two-stage configurations; the two-stage compressor is usually the best choice.

Nonlubricated reciprocating compressors are sometimes referred to as "oil-free" compressors. These compressors have wet sumps where the crankshaft is lubricated with oil; however, this sump oil is separated from the compression chamber by a distance piece and cannot enter the compression chamber. This type of compressor should be distinguished from the "oil-less" reciprocating compressors which have dry sumps with sealed bearings.

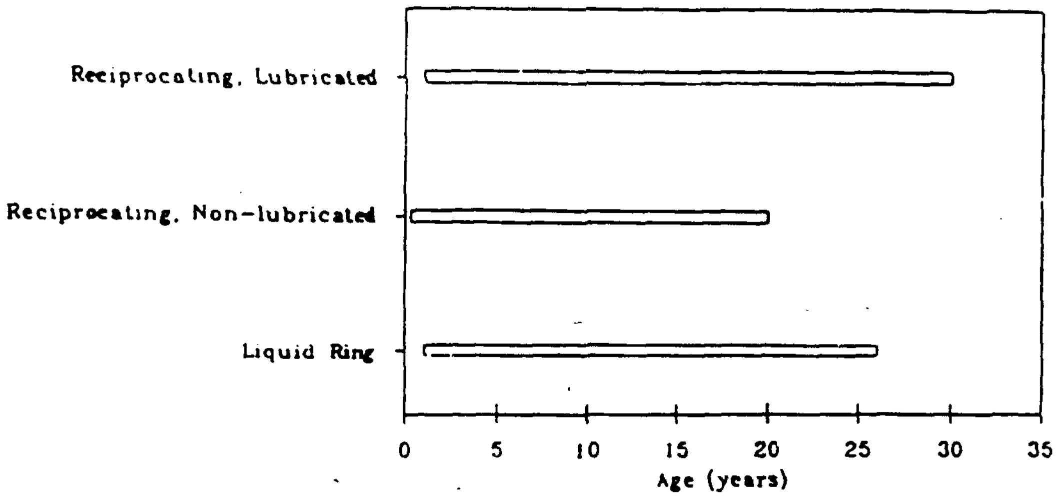


Figure 3. Age of compressors currently in use (not life expectancy).

Because oil free air is necessary for DCA, nonlubricated (oil-free) compressors would seem an obvious choice. They do, however, have a number of disadvantages.

Compared to their lubricated counterparts, nonlubricated compressors are less efficient, may have up to 30% shorter operational lives, are more costly to operate, are less reliable, and initially cost about 50% more. If not used for an extended period of time, rust may form on the cylinder walls causing excess ring wear. Because they are not lubricated, these compressors require more frequent maintenance. The approximate cost for maintenance may be $1600 a year.

3.3.6 Liquid Ring Compressors. The liquid ring compressor has a finned, squirrel cage-shaped rotor housed inside of a water filled casing. Through the rotation of the rotor, a ring of water is formed that follows the shape of the compressor's casing. As the rotor spins, water fills some of the rotor's chambers compressing the air into the discharge port. The chamber then rotates to the inlet port where the water empties from the chamber, bringing in fresh atmospheric air. As the rotor continues to rotate, the fresh air is compressed. This compression cycle repeats with each rotation. These compressors are designed for a specific pressure range and lose efficiency if operated outside of this range. Because of their design, these compressors produce a pulseless supply of compressed air. Moderately sized compressors (15 to 20 hp) are generally limited to pressures of about 7 kg/cm^2 (100 psig). Liquid ring compressors are only available in $\geq$ 7.5 hp.

Liquid ring compressors are injection cooled and do not require an aftercooler. They do not contain rubbing parts (e.g., piston rings against cylinder walls as in the reciprocating compressors) and are thus very reliable. In the simplest design, the water is used once and then discharged down the drain. In areas where water usage or cost reduction is important, the used water can be cooled, processed, and reused. Since the water ring eliminates most debris from the air, and since oil is not used, liquid ring compressors need only a general purpose coalescing filter (which should be able to remove particles larger than 1 μm) downstream from the air dryer.

Liquid ring compressors have long operational lives and produce essentially pulseless compressed air. However, they have a high initial cost (approximately 200% more expensive than lubricated reciprocating compressors) and are among the least efficient of compressors. The approximate cost to maintain these compressors may range from $800-$1100 per year, not including parts.

3.3.7 Rotary Screw Compressors. Rotary screw compressors use two screw-shaped rotors which interdigitate with each other. Rotation of the rotors, along with oil injection, compresses the air. The injected oil creates a seal between the rotors and compression chamber, lubricates, and thus removes the heat of compression. These compressors are designed for a specific pressure range and lose efficiency if operated outside of this range.

Rotary screw compressors often run continuously, and the production of compressed air is controlled through the modulation of valves. This method of

loading and unloading the compressor allows for precise control of air pressure without an excessive number of start-ups. During periods of low air usage, the compressor can also be set to shut-off and restart when needed.

The principal advantages of these compressors are their high reliability due to few moving parts, pulseless supply of compressed air, high efficiency, and reportedly long operational lives. Because of these reasons, rotary screw compressors have replaced approximately half of the industrial market share of reciprocating compressors. Rotary screw compressors are limited to 5 hp and larger. Pricing varies, but some brands of rotary screw compressors are competitively priced with their lubricated reciprocating counterparts.

3.3.8 Sliding-Vane Rotary Compressors. The sliding-vane rotary compressor contains an offset rotor which has slots that are fitted with rectangular vanes. As the rotor spins, the vanes move in and out to conform to the shape of the compressor body. Air is brought into the compressor, compressed and discharged with each rotation of the rotor. Oil injection, along with the intake air, cools the air, lubricates the rotor, and creates a seal between the rotor and the chamber. These compressors are designed for a specific pressure, and they lose efficiency if operated outside of this pressure. This type of compressor can be very quiet and is ideal where noise is a problem. If necessary, it can be placed in a small room or closet inside the clinic. Although these units offer good efficiency and a pulseless supply of compressed air, their production is limited to a few companies and they are too small (1 hp, or less) for most institutional dental clinics.

3.4 Aftercoolers

Even with intercooling or oil injection cooling, compressed air can leave the compressor at temperatures as high as 149°C (300°F), which is too hot for an air dryer and could damage it. An aftercooler not only cools the air, but also condenses most of the compressed air's moisture.

For smaller compressors (where the combined size of both compressors is less than 15 hp) the compressed air is sent to the air receiver to be cooled before going to the air dryer. For larger compressors, the air receiver may not provide enough cooling, and an aftercooler is needed. The aftercooler may be located directly after the receiver or between the compressor and the receiver. It should cool the compressed air to within 11°C (20°F) of room temperature. The aftercooler should also have a moisture separator with an automatic electrical drain valve. Aftercoolers can remove 60% or more of the compressed air's moisture.

Aftercoolers are available in air-cooled or water-cooled models. The air-cooled models are the most common and save the cost of water and descaling. The water-cooled models are smaller, more efficient, and cause less heating of room air. Water-cooled aftercoolers must have an automatic water valve.

Liquid ring compressors, regardless of size, do not require the use of aftercoolers.

3.5 Air Receivers

The air receiver cools the air, reduces compressor pulsations, and stores compressed air. The air receiver's size determines the number of compressor start-ups per hour. A smaller air receiver may require many starts per hour (more than 6) with the increased chance of electric motor overheating. Preconfigured combinations of compressors and air receivers are optimal. If a separate air receiver must be bought, its approximate size should conform to the following formula:

Receiver Size (liters; gallons) = 4 x LPM; ACFM of One Compressor at 7 kg/cm^2; 100 psig

Receiver Size (liters; gallons) = 8 x LPM; ACFM of One Compressor at 3.5 kg/cm^2; 50 psig

Receivers are usually sold in standard sizes. If the above formula gives a value between two standard sizes, the larger receiver should be selected.

The air receiver must be certified by the American Society of Mechanical Engineers (ASME) and should be galvanized inside and out to prevent rusting. Rust weakens the air receiver, clogs automatic drains, and causes downstream contamination. The air receiver must be equipped with a pressure gauge, automatic electrical drain valve, safety valve, and service valve. The service valve allows isolation of the air receiver from the downstream system. The electronic drain valve should be adjusted to drain at regular intervals so that no more than approximately 60 ml (2 oz) of water collects in the receiver at any one time.

3.6 Air Filters

Air filters are used in conjunction with air dryers to condition DCA to its required purity. The major purpose of these filters is to remove oil vapor and, to a smaller extent, to remove excess moisture and particulates. Final filtration for particulates must be removed at the point of use (e.g., DTR, laboratory) since particulates can easily originate within the building air lines. Both the general purpose and final coalescing filters must have automatic drains (electric drains are preferable due to their reliability) and differential pressure monitors (signals when the filter's cartridge needs replacement).

There are basically three types of filters used for DCA:

3.6.1. General Purpose Coalescing Filter. The general purpose coalescing filter removes particulates larger than 1 μm and removes gross oil and water aerosols. It is generally resistant to clogging and reduces the load on subsequent filters and the air dryer.

3.6.2. Final Coalescing Filter. The final coalescing filter removes particulates larger than 0.01 μm and removes oil carryover to less than 0.10 ppm w/w. It must always be preceded by a general purpose coalescing filter. The net effect of this filter is that it produces "technically oil-free air."

Below in Table 1 is a list of filters for DCA systems. The correct size of each filter is determined by the air flow of the DCA System; the company's literature must be consulted for proper sizing. This list should not be considered exhaustive.

TABLE 1. AIR FILTER SELECTION GUIDE

Company Name	**General Purpose Coalescing Filter**	**Final Coalescing Filter**	**Vapor Removal Filter**
Balston	Grade DX	Grade BX	Grade CI
Hankison	3100 Series	Aerosol	Hypersorb
Ingersoll-Rand	P-Series	C-Series	V-Series
Sullair	PF Puretech	PH Purellescer	PC Pureadsorber
Van Air	Grade B	Grade C	Grade RD
Wilkerson	Type B	Type C*	Type D**
Zurn	Particulate Filter, P	Coalescing Filter, C	Odorgard Filter, O

* Extremely High Efficiency Coalescer
** Critical Application Adsorption Filter

3.6.3. Vapor Removal Filter. The vapor removal filter is made up of activated charcoal that removes hydrocarbon impurities that patients could smell or taste; it removes oil vapors to less than 0.01 ppm w/w. In the case of lubricated compressors, this filter should always be preceded by a final coalescing filter. An air sample tap should be placed downstream from this filter. The filter cartridge needs replacement when there's a detectable odor from this tap. The vapor removal filter is the only filter that does not need a drain or differential pressure monitor.

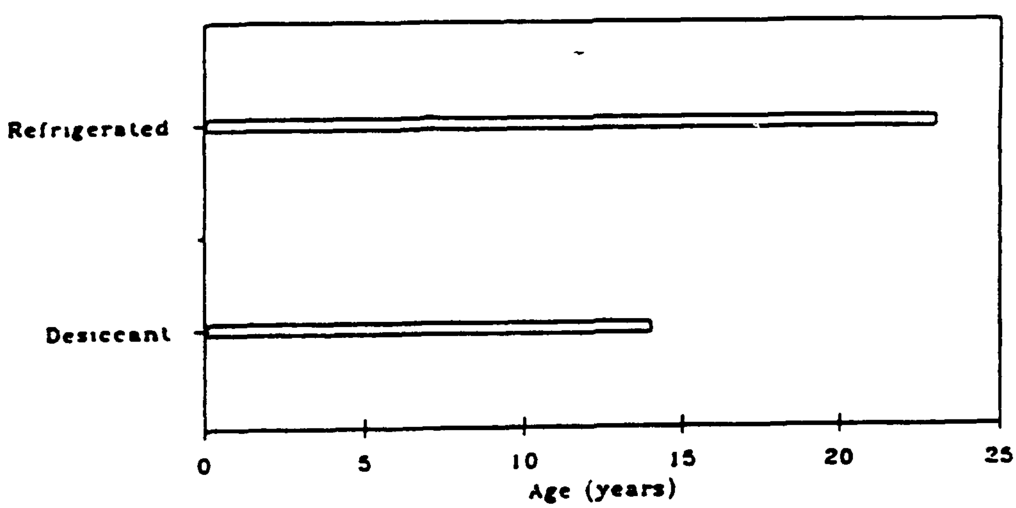


Figure 4. Age of dryers currently in use (not life expectancy).

3.7 Air Dryer

The amount of water vapor that air can contain without condensation varies with temperature and pressure. As the temperature rises air can hold more water vapor; conversely, as pressure rises, air holds less water vapor. Two types of dryers are usually employed to dry DCA. They are desiccant dryers and refrigerant dryers. Refrigerant dryers are preferred because they have less than one-third the occurrence of water in the compressed air (see Figure 5), or they are initially less expensive; and they require less maintenance than desiccant dryers. Desiccant dryers require replacement of their desiccant about once every 2 to 3 years.

Refrigerated dryers remove moisture by chilling compressed air to the required dew point. The moisture then condenses out, collects in a separator, and is discharged. These dryers are generally sized and adjusted to cool the compressed air to a dew point between 2-3°C (35°-38°F). If the refrigerant dryer is set below 2°C (35°F), it is possible that the actual temperature in certain parts of the dryer may be at or below 0°C (32°F) which will result in ice formation and clogging of the air line.

The refrigerated dryer should be noncycling (continuous operation) and adjustable to prevent freezing of the air line. It should also have a high temperature warning light (to warn of compressor problems) and an outlet air temperature gauge (to adjust and check the dew point).

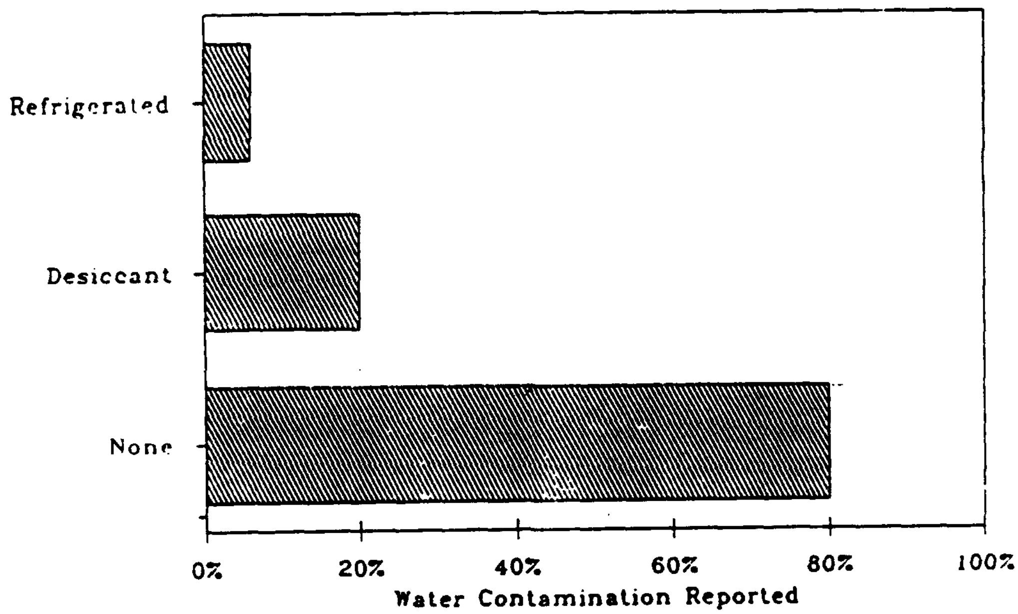


Figure 5. Water in compressed air by dryer type.

The dryer should be placed after the air receiver and before the air pressure regulator to allow the air receiver to cool the compressed air and smooth out compressor pulsations to help extend the life and efficiency of the dryer. In this location the dryer should be sized for at least 60% flow of both compressors.

Final oil vapor removal is most efficient if the air is cool. Some refrigerant dryers offer an oil coalescing filter inside the chiller to increase the effectiveness of the filter. If the dryer does not have this internal oil coalescing filter, the final coalescing filter should be placed as close to the outlet of the dryer as possible.

3.8 Air Pressure Regulator

An air pressure regulator with a 0-10.5 kg/cm^2 (0-150 psig) air gauge must be placed after the air has been dried and filtered and before the air is sent to the clinic's air lines. The regulator must be sized to handle the full capacity of both compressors and must be able to regulate the final pressure between 0-10.5 kg/cm^2 (0-150 psig). This regulator damps out the pressure fluctuations due to the compressor cycling on and off, thus, keeping the clinic's air lines at the desired pressure. The regulator must be set higher than the pressure required at the DTR in order to account for the pressure drop that occurs during full air flow conditions. For properly sized air lines this pressure drop would be 0.35 kg/cm^2 (5 psig) or less. Therefore, for a 5.6 kg/cm^2 (80 psig) air pressure at the DTR, the regulator should be set at 6.0 kg/cm^2 (85 psig). If the air lines are undersized, the regulator may need to be set higher. For the regulator to work correctly, the input pressure must always be higher than its output. A pressure differential of at least 0.7 kg/cm^2 (10 psig) is usually sufficient.

3.9 Air Lines

The building air lines should be ideally sized to carry the air flow of at least 113 lpm (4 cfm) at 7 kg/cm^2 (100 psig) to each user with no more than a 0.35 kg/cm^2 (5 psig) pressure drop from the DCA regulator to the furthest user. In large facilities, this may be difficult to achieve because of the allowable 1% per 3 m (10 ft) loss in line pressure. No building air line should be less than 13 mm (1/2 in) in diameter. The air lines and all components must be rated to at least 10.5 kg/cm^2 (150 psig) working pressure. All air lines must be routed through heated areas to prevent exposure to temperatures below 4°C (40°F).

Pipes should be type "K" or "L" seamless copper tubing that has been washed and degreased. All valves and fittings should be wrought copper, brass, or bronze. All joints should be made with silver brazing alloy except for valves or equipment requiring threaded pipe connections. Threaded pipe connections should be made by tinning male threads with soft solder.

4. SPECIAL TOPICS

4.1 Wet Versus Dry Receiver

The preferred design places the dryer after the air receiver (sometimes called a wet receiver configuration). This configuration allows the air receiver to cool the air and damp-out compressor pulsations. For smaller DCA

systems the air receiver also functions as an aftercooler. To limit the water contained in the air receiver, it is equipped with an electronic drain. Because the air receiver stores compressed air and equalizes flow, the air dryer need only be sized to handle 60% of the capacity of both compressors.

A secondary design places the dryer before the air receiver (called a dry receiver configuration). This configuration has a number of disadvantages. The air leaving the compressor is hot; consequently, it must be cooled by a large aftercooler to within 3°C (5°F) of room temperature. This aftercooler must be equipped with a separator and automatic drain. The pulsations from a reciprocating compressor will cause increased stress on the dryer and can shorten its operational life. The dryer must also be sized to handle the full air capacity of both compressors because the air receiver is no longer functioning as an air flow buffer. The dry receiver design when compared to the standard wet receiver:

1. Requires an aftercooler for all DCA Systems.
2. Requires a larger aftercooler (3° versus 11°C or 5° versus 20°F temperature drop).
3. Requires a larger dryer (100% versus 60% compressor capacity).
4. Results in a shorter operation life for the dryer.

Also see Special Topic, #4.3.

4.2 Oil Contaminated Air Lines

The building's air lines can become contaminated by oil if the previous DCA System was not properly designed, or if an oil coalescing filter ruptures. This problem can be dealt with by first correcting the problem (e.g., installing or replacing the coalescing filters) then flushing the lines with a degreaser or installing a disposable coalescing filter at each dental unit. Balston makes a line of disposable coalescing filters (part number 9922-11-BX, approximately $17.00 each) that can be used at each DTR.

4.3 Sterile Compressed Air

A frequently expressed concern is that the DCA system may become contaminated. The air receiver is commonly cited as the problem area. All compressed air systems collect water somewhere within the system. The important point is to design the system so that this water will collect in areas where it can be drained before appreciable bacterial or fungal growth occurs. Areas that are ideal for collecting and draining water are the aftercooler, receiver, filters, and dryer. If the DCA System is correctly designed and maintained, no more than a few ounces of water will collect before being drained off. With the use of electric drains, this water will be drained within an hour of collection. Note that wet receiver systems are acceptable even for medical grade compressed air.

The entire DCA cannot be made sterile. If sterile air is required, the only possible method is the use of sterile air filters in each DTR just prior to the point of use. These filters must be removable and sterilizable. All air lines after these filters must also be removable and sterilizable. Filters that meet the requirements of the FDA for sterile air are available from Balston (see Balston's Bulletin P-90E) and Zander Filter Systems.

4.4 Compressed Air for Surgical Handpieces

The quality of air described in this document will meet the requirements of most surgical handpieces (DynaDent, Hall, and Stryker). Sterility is not an issue since the air used to operate these handpieces is discharged well away from the surgical site. To meet the required air pressure for some surgical handpieces the main air pressure regulator will likely need to be set at a higher pressure (e.g., 8.1 kg/cm^2; 115 psig) and the lead and lag compressors' cut-in and cut-out pressures adjusted upward.

Adjusting the DCA pressure upward will slightly increase wear on the compressors and will result in a small increase in the use of air by other areas of the clinic. The advantages of using compressed air for surgical handpieces, however, usually outweigh the expense, danger and additional work involved with using tanks of compressed nitrogen as the source for operating the handpieces.

In the future, surgical handpieces will probably be predominantly electrically powered.

4.5 Drying Air for Air Lines Exposed to Cold Conditions

If the DCA lines are routed through unheated areas which are exposed to temperatures less than $0^{o}C$ ($32^{o}F$), the dew point of the compressed air must be at least $3^{o}C$ ($5^{o}F$) lower than the coldest temperature expected to avoid condensation and freezing in the air lines.

Two methods which may be used to obtain low dew points are drying at higher pressures or using desiccant dryers.

a. Pressure Method:

Table 2 shows the relationship of air pressure versus dew point at constant temperature. By finding a dew point in the table under a specific pressure and reading across to the left, you can find the new dew point if that air were expanded to a lower pressure. For example, if air with a dew point of $3^{o}C$ ($38^{o}F$) at 8.4 kg/cm^2 (120 psig) is expanded to a pressure of 5.6 kg/cm^2 (80 psig), by reading across to the left on the table we can see that the air's new dew point will be $-1^{o}C$ ($30^{o}F$). By reading further across to atmospheric pressure (0 psig) the air's dew point will be $-22^{o}C$ ($-8^{o}F$).

For the few situations where air lines are exposed to low temperatures, (0 to -4°C; 32°F to 25°F), adjustment of the air pressure at the dryer will be necessary. By increasing the air pressure at the dryer and keeping the pressure to the building air lines constant, a low dew point can be maintained in the air lines. For example (referring to Table 2), if the dryer is maintaining a dew point of 3°C (38°F) at a pressure of 180 psig, and the regulator reduces this air to a pressure of 80 psig, the dew point of the air will be (-7°C) (20°F). This dew point is sufficient to permit adequate flow through air lines exposed to temperatures as low as -4°C (25°F). If the air lines are exposed to temperatures below -4°C (25°F), a desiccant dryer will be needed.

TABLE 2. AIR PRESSURE

(psig)								kg/cm^2							
0	60	80	100	120	140	160	180	0	4.2	5.6	7.0	8.4	9.8	11.2	12.6
3	36	42	48	52	56	60	64	-19	2	6	9	11	13	16	18
1	34	40	46	50	54	58	62	-18	1	4	8	10	12	14	17
0	32	38	44	48	52	56	60	-18	0	3	7	9	11	13	16
-2	31	36	42	46	50	54	58	-19	-1	2	6	8	10	12	14
-3	30	35	40	44	48	52	56	-19	-1	2	4	7	9	11	13
-4	28	34	38	42	46	50	54	-20	-2	1	3	6	8	10	12
-6	26	32	36	40	44	48	52	-21	-3	0	2	4	7	9	11
-8	24	30	34	38	42	46	50	-22	4	-1	1	3	6	8	10
-9	23	28	32	36	40	44	48	-23	-5	-2	0	2	4	7	9
-10	22	26	30	34	38	42	46	-23	-6	-3	-1	1	3	6	8
-12	20	24	28	32	36	40	44	-24	-7	-4	-2	0	2	4	7
-13	18	22	27	30	34	38	42	-25	-8	-6	-3	-1	1	3	6
-14	16	21	26	29	32	36	40	-26	-9	-6	-3	-2	0	2	4
-16	14	20	24	28	30	34	38	-27	-10	-7	-4	-2	-1	1	3
-18	13	18	22	26	28	32	36	-28	-11	-8	-6	-3	-2	0	2
-20	12	16	20	24	26	30	32	-29	-11	-9	-7	-4	-3	-1	0
Dew Point (°F)								Dew Point (°C)							

b. Desiccant Drying Method:

We do not recommend the use of desiccant dryers unless very low dew points are required. Refrigerant dryers are normally the best choice since they are less expensive, require less maintenance, and are more reliable. For those few clinics requiring very low dew points, the following should be helpful. These dryers contain a desiccant material that adsorbs moisture from the compressed air by physical means. When the desiccant becomes saturated with water, it is reactivated by removing this moisture. Reactivation can be accomplished by two methods:

(1) Heatless (or Pressure Swing) Method where between 5% to 20% of the previously dried compressed air is bled back through the desiccant in a controlled manner. Since the compressor must be sized larger to provide this purge air, this type of unit is expensive to operate.

(2) Heat Reactivated Method where the desiccant is dried by heated room air. This method does not require the compressor to be oversized and is less expensive to operate than the heatless method. The initial cost of this system, however, is more than the heatless system.

To minimize conflict with the compressor's operation, two desiccant-filled cylinders are used. One cylinder dries compressed air, while the second one is reactivated. When the first cylinder becomes saturated with moisture, then the operating mode of the two cylinders is exchanged. These twin cylinder systems can provide continuous air drying and are preferable to single cylinder systems (see **Special Topic #4.6**).

Desiccant drying media loses capacity with age and needs to be replaced approximately every 2 to 3 years. Access to the desiccant should be designed into the dryer to expedite desiccant replacement.

The three types of desiccant media commonly used are:

(a) Activated Alumina, which is liquid tolerant, can dry to a dew point of $-40^{o}C$ ($-40^{o}F$). It has high adsorption capacity.

(b) Silica Gel, which must be protected from liquid (usually by a layer of activated alumina), can dry to a dew point of $-40^{o}C$ ($-40^{o}F$). It can have a chemical humidity indicator added (at about the 50% relative humidity, its color changes from blue for dry air, to pink for wet air).

(c) Molecular Sieve can obtain dew points as low as $-73^{o}C$ ($-100^{o}F$), but it is expensive and has low adsorption capacity.

Due to their physical method of moisture absorption, desiccant dryers will also capture other impurities in the compressed air, namely oil vapor. Unfortunately, once the oil has been adsorbed it cannot be removed from the desiccant. Thereafter, it does not capture moisture adequately and its effective life is reduced. When these dryers are used with lubricated compressors, an oil coalescing filter must be placed upstream of the dryer. Desiccant pellets break down to a fine abrasive dust with time; thus, an after-filter that removes particles larger than 1 μm must be installed between the dryer and the clinic.

4.6 Comments on "Dental Air Compressors"

Many of the systems sold as "dental air compressors" have one principal advantage over the industrial compressors recommended in this document -- they are quiet. If a compressor must be placed near occupied rooms and the building cannot be modified for adequate sound control, one of the dental compressor packages is likely to be the best choice. Study the options carefully. The problems with many of the dental compressor packages are:

a. Compressors are single stage and suffer from the problems discussed previously in the compressor section.

b. High oil carry-over rates require careful monitoring of the oil level.

c. Compressors frequently use only one desiccant column. Compressor systems using only one desiccant column dry compressed air during the compression cycle and then regenerate the desiccant by the heatless method when the compressor stops. These single cylinder systems are extremely sensitive to high humidity, high temperatures and extended duty cycles since they only regenerate when the compressor is not running. This system must always have an aftercooler with an air/water separator and automatic drain before the desiccant column. To be sure there is enough time to regenerate the desiccant, these systems should be sized with a very low duty cycle, sometimes as low as 30%. These dryers are generally not able to maintain dew points below $2^{o}C$ ($35^{o}F$). The desiccant in the column must be replaced every 2 to 3 years.

Most of the dental compressor packages will not meet the air quality requirements specified in this document. Additional filters and air dryers may need to be added to bring them into compliance.

4.7 Comments on Air Operated Evacuation Systems

Wherever possible, central vacuum is preferable to an air operated evacuation system. Central vacuum systems produce better suction, do not produce septic aerosols in the DTR, and do not require an oversized compressor for its operation. Air operated evacuation systems should only be used where the facility design precludes the use of a central vacuum system.

5. CONCLUSIONS

As mentioned in the introduction, this report updates the information provided by USAFSAM-TRs 86-7 and 86-8. Major changes from or additions to these previous documents are:

1. Total compressor capacity increased to a minimum of 113 lpm (4.0 cfm) at 7 kg/cm^2 (100 psig) per DTR.

2. A clarified recommendation for lubricated compressors with proper oil coalescing filters.

3. A limit of 0.35 kg/cm^2 (5 psig) air line loss in building air lines.

4. Discussion of system air pressures.

5. Added selection checklist for compressed air systems.

6. Added an annual inspection checklist for the compressed air system.

Much of the information included in this report was taken from the results of a survey received from dental facilities worldwide. Whenever

possible, a recommendation was made concerning a particular system or component. Table 3 is a summary of air compressor requirements for DTRs.

TABLE 3. AIR COMPRESSOR REQUIREMENTS FOR DTRs (CUBIC FEET PER MINUTE)

NO. OF DTRS	REQUIRED CFM/LPM	MOTOR SIZE (HORSEPOWER)
1-3	2-6 57-170 LPM	0.5-1.5
4	7.2 204 LPM	1.5
8	11.2 317 LPM	3.0
12	16.8 476 LPM	5.0
16	22.4 634 LPM	7.5
20	28.0 793 LPM	7.5
24	33.6 952 LPM	7.5
28	33.6 952 LPM	7.5
32	38.4 1087 LPM	10.0
36	43.2 1223 LPM	15.0
40	48.0 1359 LPM	15.0
50	60.0 1699 LPM	15.0
60	72.0 2039 LPM	15.0
60+	SEE NOTE 4	SEE NOTE 4

NOTE 1: 1-3 DTRs, 100% USE FACTOR, PROPRIETARY BUY

NOTE 2: ABOVE VALUES DO NOT INCLUDE DENTAL LAB AIR

NOTE 3: CFM REQUIREMENTS BASED ON 70% USAGE FOR LESS THAN 28 DTRs AND 60% USAGE FOR 28 OR MORE

NOTE 4: CALCULATIONS FOR MORE THAN 60 DTRs:

NO. OF DTRs X 2.0 CFM X .60 = CFM REQUIREMENT

OR

NO. OF DTRs X 57 LPM X .60 = LPM REQUIREMENT

NOTE 5: FOR M^3/MIN CARRY OUT LPM 3 DECIMAL PLACES TO LEFT
1087 LPM = 1.087 = 1.1 M^3/MIN

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GLOSSARY

μm Micrometer; one-millionth of a meter.

acfm Average cubic feet per minute. This is a flow rate stated by manufacturers which is the average flow rate when a compressor pumps a defined volume (usually the receiver) from atmospheric to a specified pressure. This value will be greater than the rated full-pressure capacity of the compressor.

aftercooler A device that cools compressed air immediately after compression to its final pressure. Aircooled aftercoolers are the most common type in dental facilities.

air receiver The air tank where compressed air is stored.

alternator An electrical device that controls the start-up and stopping of duplex air compressors. It helps to even out the mechanical wear on the two compressors.

ASME American Society of Mechanical Engineers. This society sets safety standards for mechanical systems.

AVS Air Venturi System. If the facility design allows for a central vacuum system, it is preferable to an Air Venturi System.

Base-mount Compressor Compressor system in which an electric motor and compressor are mounted on a base independent of the air receiver.

cfm Cubic feet per minute.

CIM Cubic inches per minute.

DCA Dental Compressed Air.

dew point The temperature where water vapor will condense into liquid water if a mixture of air and water vapor is cooled at a constant pressure. The dew point is the temperature at which the actual vapor pressure equals the saturated vapor pressure, i.e., 100% relative humidity. The dew point of a sample of air will remain the same as the temperature of the air sample rises. See also **Relative Humidity**.

distance piece A connector and chamber between a wet sump and the compression chamber. The chamber has oil seals at both ends designed to prevent oil from migrating from the sump to the compression chamber. The connector transmits forces from the crank to the pistons through this space.

dry receiver An air receiver that stores air that has been fully dried.

DTR Dental Treatment Room.

duty cycle A percentage value that is calculated by:

$$\text{duty cycle} = T_c \times 100/\ (T_c + T_i)$$

T_c = Time Compressor is Compressing Air or Loaded
T_i = Time Compressor is not Compressing Air or Unloaded

FAD Free air delivery, usually measured at $100^{o}F$.

HP Horsepower for compressor's electric motor.

helical-lobe rotary compressor Another name for rotary screw compressor.

intercooler An air cooling device that is used between stages of a double stage compressor.

lag compressor The compressor that starts if the lead compressor is unable to provide enough air flow to meet the air demand.

lead compressor The first compressor that starts to supply compressed air when the air pressure drops below a preset value.

loading and unloading When a compressor is loading and unloading, the motor runs continuously and the supply of compressed air is limited by adjusting the compressor's valves.

Lpm Liters per minute.

ppm w/w Parts per million by weight.

psi Pounds per square inch.

psia Pounds per square inch absolute. This is the air pressure above a complete vacuum.

psid Pounds per square inch difference. This term is usually used to measure air pressure loss across air lines or devices.

psig Pounds per square inch gauge. This term refers to air pressure above atmospheric air pressure. Conversion to psia is: psia = psig + 14.7psi

relative humidity A measure of the degree of water vapor saturation in air. It is the ratio of the actual water vapor pressure to saturated water vapor pressure. As the temperature of a sample of air rises, its relative humidity will decrease.

single phase electricity An electrical circuit with only one alternating electrical wave form, characterized by having two wires (excluding ground).

single-stage compressor A compressor that compresses air from atmospheric to the final pressure in one compression cycle. Single-stage compressors are best suited for pressures of 80 psig and lower.

skid-mounted compressor An electric motor and compressor that are mounted on a skid (i.e. base) independent of the receiver. The receiver is located at a distance from the base-mounted compressor.

sump Space where the main crank and bearings operate. A "wet sump" indicates that a pool of oil is at the bottom of the sump and the movement of the main crank and bearings splashes oil up on the piston cylinders and rings lubricating them. A "dry sump" indicates that the sump lacks oil and that the main bearings are sealed with a small amount of lubricant.

TEFC Total enclosed fan cooled. TEFC motors are intended to be used in dusty environments but are not usually needed for DCA.

triple phase electricity An electrical circuit with three alternating electrical wave forms, characterized by three wires (excluding ground).

two-stage compressor A compressor that compresses air in two stages and cools the air between the stages. This type of compressor is more efficient for pressures above 5.6 kg/cm^2 (80 psig) than a single-stage compressor.

wet receiver A receiver storing compressed air containing water vapor which is passed through the air dryer to remove moisture.

COMPANY ADDRESSES

Notes after each company are provided by the authors and are offered to provide some insight into their products and policies. Most companies will only provide prices for their products by written quote. Most of these addresses are for the corporate headquarters who will most likely refer you to local dealers. The reader is advised to contact more than one vendor to get a range of prices. This listing is not intended to be all inclusive, nor is it a recommendation. A reader who is aware of additional manufacturers should feel free to investigate their product lines.

Balston, Inc.
703 Massachusetts Avenue
P.O. Box C
Lexington MA 02173
Phone: 1-800-343-4048

Specializes in air filters for special applications as sterile air, oil coalescing filters, etc. They do offer a unique small oil coalescing filter that could be used in the DTR.

Bauer Compressors Inc.
1328 Azalea Garden Road
Norfolk VA 23502
Phone: (804) 855-6006

Sells a complete line of rotary screw, lubricated and oil-free reciprocating air compressors.

Corken International Corporation
3805 N.W. 36th Street
Oklahoma City OK 73112
Phone: (405) 946-5576

Manufactures a complete line of nonlubricated air compressors.

Custom Vacuum
Den-Tal-Ez
P.O. Box 896
Valley Forge PA 19482
Phone: 1-800-845-8480

Sells small dental specific compressors (1, 2, 3 hp). These compressors are quiet, but expensive, and may need modification to meet this DCA Standard.

Hankison
Canonsburg PA 15317
Phone: (412) 745-1555

Sells a wide range of aftercoolers, air filters, desiccant air dryers, and refrigerated air dryers. Company's literature is very informative.

Ingersoll-Rand Air Compressors
P.O. Box 1126
Wall Street Station
New York NY 10005
Phone: 1-800-847-4041 or (212) 775-1395

Sells a wide range of reciprocating compressors (lubricated and nonlubricated), rotary screw compressors, aftercoolers, air dryers and air filters. Offers a number of products at a special Government rate. They are the most common supplier of dental air compressors for the Federal Services. Company's literature is very informative.

Kaeser Compressors
P.O. Box 7416
Fredericksburg VA 22404
Phone: (703) 898-5520

Sells air filters, air dryers, and rotary screw compressors.

Luckman Corporation
1930 Old York Road
Abington PA 19001
Phone: (215) 659-1664

Sells a small dental specific rotary vane compressor (2 hp). This compressor is quiet, but initially expensive, and may need modification to meet this DCA Standard.

Nash Engineering
1115 Goodnight Trail
Houston TX 77060-1112
Phone: (713) 821-9514

Specializes in water ring compressors (7.5 hp and larger). Company's literature is very informative.

Quincy Compressor
3501 Wismann Lane
P.O. Box C2
Quincy IL 62305-3116
Phone: 1-800-747-0547 ext 200 / (217) 222-7700

Sells a wide range of reciprocating compressors (lubricated and nonlubricated), rotary screw compressors, aftercoolers, air dryers and air filters. Offers lubricated reciprocating compressors to the Government at the wholesale rate if ordered from the company. Company's literature is very informative.

SIHI Pumps, Inc.
303 Industrial Blvd.
P.O. Box 100
Grand Island NY 14072
Phone: 1-800-828-6861 or (716) 773-2330

Specializes in water ring compressors (7.5 hp and larger).

Sullair
3700 East Michigan Blvd
Michigan City IN 46360
Phone: 1-800-348-2722 or (219) 879-5451

Sells rotary screw compressors, air filters, and air dryers. Their smaller rotary screw compressors (5, 10, and 15 HP) are listed on a GSA price schedule and are competitive with the lubricated reciprocating compressors.

Van Air Systems Inc.
2950 Mechanic Street
Lake City PA 16423
Phone: (814) 774-2631

Specializes in aftercoolers, air dryers and air filters. Company's literature is very informative.

Wilkerson Corporation
P.O. Box 1237
Englewood CO 80150
Phone: (303) 761-7601

Specializes in aftercoolers, air dryers and air filters. Company's literature is very informative.

Zander Filter Systems, Inc.
5500 Oakbrook Parkway
Suite 110
Norcross Georgia 30093
Phone: (404) 446-3614

Specializes in air dryers, and air filters, including sterile air filters.

Zeks Air Dryer Corporation
Malvern Industrial Park
Box 396
Malvern PA 19355
Phone: 1-800-888-2323

Specializes in aftercoolers, air dryers, and air filters.

Zurn
One Zurn Place
Box 2000
Erie PA 16512
Phone: (814) 452-2111

Sells a complete line of air filters.

DENTAL COMPRESSED AIR EQUIPMENT SELECTION CHECKLIST

Calculations:

1. Number of Dental Treatment Rooms
   ______ x 57 LPM (2.00 CFM) = ________
2. Number of Air Venturi Systems
   ______ x 27 LPM (4.50 CFM) = ________
3. Number of outlets in dental laboratory
   ______ x 7 LPM (0.25 CFM) = ________
4. If the value in #3 is $\geq$ 4.00, enter 4.00, or else enter value from #3 = ________
5. Add 1, 2, and 4 (Total LPM/CFM required per compressor) = ________

   Multiply value from #5 by usage factor __x 1.2__

6. Size of air dryer needed = ________

   Multiply value from #6 by 57 LPM (2.00 CFM) __x 2.0__

7. Total air flow required for the DCA System at 7 kg/cm^2 (100 psig) = ________

Air Compressor

Size: From #5 under calculations
Required options:

____ Double-stage compressor (if reciprocating compressor)*
____ Duplex compressors; each must provide the air flow from #6
____ Control panel with alternator
____ Low oil or high temperature shutdown switch (lubricated compressors only)
____ Intercooler

____ Aftercooler (only necessary if the compressor is 7.5 hp or larger)
____ Aftercooler has moisture separator with automatic electric drain
____ Aftercooler can cool within 11°C (20°F) of room temperature
____ Aftercooler has less than 0.14 kg/cm^2 (2 psi) pressure drop at full air flow

____ Low pressure alarm
____ Air receiver is internally and externally rustproofed (galvanized preferred)
____ Air receiver is ASME certified
____ Air receiver has pressure gauge
____ Air receiver automatic electric drain
____ Air shut-off valve

Additional things to consider:

- ____ Will the compressor assembly fit through halls, doorways, and have at least 0.9 m (36 in) of clearance on all sides when installed
- ____ Order the correct motors to match your facility's electrical power supply (voltage, phase, and frequency)
- ____ Three-phase motors are preferable to single phase motors
- ____ If the elevation of your installation is over 1500 meters (5,000 ft), check with the manufacturer for special compressors and motors

Air Dryer

Size: From #6 under calculations.

Required options:

- ____ Refrigerated air dryer**
- ____ Can maintain dew point at or below 3° ($38^{\circ}F$) at 100 psig with room temperature at $38^{\circ}C$ ($100^{\circ}F$)
- ____ Has no more than a 0.35 kg/cm^2 (5 psi) pressure drop during full air flow conditions
- ____ Is noncycling
- ____ Has a high temperature warning light
- ____ Has outlet temperature gauge
- ____ Automatic electric drain

Additional item to consider:

- ____ A general purpose oil filter may be needed before the dryer (if an oil-lubricated compressor is used)

Air Filters

Size: From #7 under calculations.

Requirements:

A. General Purpose Coalescing Filter (required on all systems)

- ____ Less than .07 kg/cm^2 (1 psi) air pressure drop (when clean and dry) at air flow given in #7
- ____ Removes particles larger than 1 μm
- ____ Equipped with automatic drain (electric preferred)
- ____ Differential pressure monitor

B. Final Coalescing Filter (required only on lubricated systems)

____ Less than 0.14 kg/cm^2 (2 psi) air pressure drop (when clean and dry) at air flow given in #7
____ Removes particles larger than 0.01 μm
____ Removes oil carryover to less than 0.10 ppm w/w
____ Equipped with automatic drain (electric preferred)
____ Differential pressure monitor

C. Vapor Removal Filter (required only on oil lubricated systems)

____ Less than 1 psi air pressure drop (when clean and dry) at air flow given in #7
____ Removes oil carryover to less than 0.01 ppm w/w
____ Will be fitted with a downstream tap for sampling air

Air Pressure Regulator

Requirements:

____ Has an air pressure gauge with a range of 0-10.5 kg/cm^2(0-150 psig)
____ Can handle air flow given in #7

Building Air Lines

Requirements:

____ Will have no more than 0.35 kg/cm^2 (5 psi) pressure loss at the furthest user during full flow conditions
____ Smallest diameter is not less than 13 mm (0.5 in)
____ Rated at 10.5 kg/cm^2 (150 psig) working pressure
____ Type "K" or "L" seamless copper tubing, washed and degreased
____ Valves and fittings are wrought copper, brass, or bronze

* For a dental laboratory if the compressor will not be operated above 5.6 kg/cm^2 (80 psig) then a single stage compressor is acceptable.

** A desiccant air dryer is only acceptable if compressed air dew point must be kept below -7°C (20°F); see Special Section 5 for more information.

SUGGESTED ANNUAL EXAMINATION OF THE DENTAL COMPRESSED AIR SYSTEM

The DCA System should be inspected annually by the dental staff together with those responsible for maintenance. The purpose is to familiarize the dental staff with their DCA System, review maintenance procedures accomplished during the past year, and identify equipment that should be replaced. Regular inspections can help identify and correct small problems before they cause work stoppages. Remember, a properly selected and maintained DCA System can last 20 to 30 years.

Specific instructions from the manufacturer take priority over these instructions.

Date of Inspection: Name of Inspectors:

Location of Inspection:

Disconnect Electrical Power Before Starting Inspection
When discharging air, wear safety glasses and stand clear of exhaust.

Air Compressor

_____ Crankcase oil is at the correct level
_____ Oil and oil filter is changed at least once a year and recorded in the maintenance log
_____ Air intake filter is clean and replaced yearly
_____ Drive belts are in place and adjusted to the correct tension
_____ Operate drain valves manually; no more than a few ounces of water should be discharged from any valve
_____ Operate all safety valves manually
_____ Intercooler fins are free of dust and obstructions
_____ Test low air pressure alarm
_____ Check foundation bolts for tightness
_____ On reciprocating compressors the valves should have been removed and cleaned during the past year

Aftercooler

_____ Aftercooler fins are free of dust and obstructions
_____ Manually open drain valve; no more than approximately 60 ml (2 oz) should be discharged from any valve
_____ Water-cooled unit should be checked for mud and scale accumulations

Reconnect electrical power for the rest of the inspection.

Air Compressors

_____ Perform pump up test*
_____ Listen for unusual sounds that may indicate problems
_____ Inspect all air lines, listening for leaks and testing with soap and water if necessary

Refrigerated Dryers

_____ Fins and openings are free of dust and obstructions

_____ Manually open drain valve; no more than a few ounces should be discharged from any valve

_____ Outlet air temperature gauge setting is between 2-3^{o}C (35-38^{o}F)

_____ High temperature light is not on

Desiccant Dryers

_____ Check operating manual for inspection guidelines

_____ Desiccant should have been replaced within the last 3 years

Coalescing Filters

_____ While the clinic is using air, check the differential pressure monitors for clogged filters

_____ Manually open drain valves; no more than a few ounces should be discharged from any valve

Vapor Removal Filter

_____ Slightly crack open air sample tap; if there is a detectable odor, the cartridge needs replacement

* **Performance Pump Up Test**

1. Stop Compressors
2. Discharge all air from the DCA System
3. Close the air receiver's shut off valve
4. Start compressor
5. Record time needed to raise air pressure from 0-7 kg/cm^2 (0-100 psig) ("pump-up time")
6. Open the air receiver's shut off valve
7. Compare pump-up time with last year's value or manufacturer's value. A substantial increase in time indicates that the compressor is in need of repair

Last year's pump-up time: _______ This year's pump-up time: _______